

## CLAIMS

1. A device adapted to receive multiple fragments representing overlapping data for a pixel location and output at most one blended pixel, comprising:

a first storage;

5 a fragment buffer that holds multiple fragments for overlapping data; and

one of instructions and hardware that causes said device to

10 detect in the fragment buffer a fragment representing predetermined one of closest and furthest visible data for the pixel location,

15 blend the predetermined one with any preexisting contents of the first storage that represent data that is to be visible in an output image, and

20 repeat the detecting and blending until no more unprocessed fragments representing visible image data are left in the fragment buffer for the pixel location;

25 wherein detection of the predetermined one is performed using a Z-value storage to isolate during a first pass through the fragment buffer a Z-value corresponding to the predetermined one, and to match during a second pass through the fragment buffer contents of the Z-value storage against fragment buffer contents to isolate the predetermined one.

2. A device according to claim 1, wherein said device composites back-to-front and further comprises one of instructions and hardware that processes contents of the fragment buffer by:

- 5 first, detecting any fragment representing a closest opaque data, moving such fragment to the first storage to overwrite any prior contents and removing such fragment from further consideration as fragment buffer contents;
- 10 second, examining depth of fragments in the fragment buffer relative to any closest opaque data and removing from further consideration any fragments obscured by closest opaque data; and
- 15 third, compositing any fragments for the pixel location remaining in the fragment buffer with contents of the pixel value storage in back-to-front order.

3. A device according to claim 1, wherein each fragment for the pixel location further has associated with it a sub-pixel mask and wherein said device further comprises one of instructions stored and hardware

5 associated with the device that implements antialiasing using the sub-pixel mask to blend visual contributions by each fragment representing visible data in dependence upon the associated mask.

4. A device according to claim 1, wherein:
- the fragment buffer stores fragments that collectively representing multiple pixel locations;

5 the pixel value storage is part of a frame  
buffer, the frame buffer having at least one  
first storage location for each pixel within an  
image region; and

10 said device further comprises one of  
instructions and hardware that composites data  
by successively examining fragments in the  
fragment buffer and by combining those fragments  
into the frame buffer as the predetermined one  
for the corresponding pixel location or  
15 returning them to the fragment buffer if they  
are not the predetermined one, and by repeating  
the combining or returning until the fragment  
buffer is completely empty.

5. A device according to claim 4, wherein said  
device composites back-to-front and processes each pixel  
location by:

5 first, detecting any fragment representing a  
closest opaque object, moving such fragment to  
the first storage and removing such fragment  
from further consideration as fragment buffer  
contents;

10 second, examining depth of fragments in the  
fragment buffer relative to any closest opaque  
image object and removing from further  
consideration any fragments representing data  
obscured by a closest opaque object; and

15 third, compositing any fragments remaining in  
the fragment buffer corresponding to the  
particular pixel location with contents of the  
first storage in back-to-front order.

6. A device according to claim 5, wherein said the fragment buffer is a first-in, first out memory and wherein said device examines successive fragments in the fragment buffer and either composites those fragments if  
5 they represent furthest visible data for a pixel location, or returns those fragments to the fragment buffer if they do not represent furthest visible data for a pixel location, and performs the compositing or returning until the fragment buffer is completely empty.

7. A device according to claim 1, wherein said device further comprises a state generation unit that produces state information to indicate at least:

5 a state that there is a fragment for to the pixel location representing relatively closer opaque data than other fragments in the fragment buffer which have not yet been invalidated; and

10 a state that there are at least two fragments each representing visible data for a corresponding pixel location.

8. A device according to claim 7, wherein:

5 the first storage is part of a frame buffer having a unique address space for each pixel location, the unique address space for each pixel location adapted to store color and intensity information as well as state information for the pixel location.

9. A device according to claim 1, wherein:

the Z-value storage and the pixel value buffer are part of a frame buffer;

5           said device further comprises a second Z-value storage; and

10           the Z-value storage of the frame buffer and the second Z-value storage are used in alternating fashion in a manner where one Z-value storage holds a Z-value for fragment representing a  
15           predetermined one of closest and furthest visible data for a particular pixel location that will be moved and removed from the fragment buffer during a current pass through the fragment buffer, while the other Z-value storage is used to sort Z-values for other fragments for the particular pixel location that will be moved and removed during a subsequent pass through the fragment buffer.

10.   A device according to claim 1, wherein said device composites front-to-back and further includes one of instructions and hardware that causes said device to process fragment buffer contents by:

5           detecting a fragment representing transparent data for a pixel location;

10           storing a depth value of a detected fragment in a Z-value storage if the depth value for the fragment indicates data for the fragment is relative closer to the desired viewing perspective than data for previously detected fragments;

15           using the stored depth value to identify the fragment representing closest remaining visible data for the pixel location, compositing the fragment with contents of the pixel value storage for that particular pixel location, and

20

inhibiting further consideration of such  
detected fragment from further consideration as  
fragment buffer contents; and

repeating the processing of contents of the  
fragment buffer until no more fragments are left  
for consideration in the fragment buffer for the  
particular pixel location.

11. A method of arbitrating multiple fragments  
representing overlapping data for a pixel location and  
outputting at most one representation for that pixel  
location, using a pixel value storage, a fragment  
5 buffer, and hardware logic, said method comprising:

storing in the fragment buffer multiple  
fragments representing data overlapping in at  
least one pixel location;

10

using the hardware logic to index, detect and  
remove from the fragment buffer a fragment  
representing a predetermined one of closest and  
furthest visible image data at the pixel  
location;

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combining that predetermined one with any  
preexisting pixel value storage contents that  
represents visible data; and

repeating the using and combining until no more  
fragments are left in the fragment buffer that  
correspond to the pixel location.

12. A method according to claim 11, further  
comprising fragments back-to-front by:

first, detecting any fragment representing  
closest opaque data, moving such fragment to the

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5 pixel value storage to overwrite any prior contents and removing such fragment from further consideration as fragment buffer contents;

second, examining depth of fragments in the fragment buffer relative to any closest opaque image data and removing from further consideration any fragments that are obscured by closest opaque data; and

third, compositing any fragments remaining in the fragment buffer with contents of the pixel value storage in back-to-front order.

13. A method according to claim 11, wherein each fragment for the pixel location further has associated with it a sub-pixel mask and wherein said method further comprises performing antialiasing using the sub-pixel mask to blend visual contributions by each fragment for the pixel location in a manner responsive to values of each mask.

14. A method according to claim 11, further comprising:

generating state information indicating at least

a state that there is opaque data for the pixel location relatively closer than other data represented by fragment buffer fragments which have not yet been invalidated, and

a state that there are at least two fragments representing visible data for the pixel location; and

using the state information for the pixel location to process fragments in a manner dependent upon the state information.

15. A method according to claim 11, further comprising compositing fragments front-to-back by:

detecting a fragment representing transparent data for a pixel location;

5 storing a depth value associated with a detected fragment in a Z-value storage if the depth value indicates that data for the detected fragment is relatively closer to the desired viewing perspective than data for previously detected  
10 fragments;

using the stored depth value to determine the closest transparent data at the particular pixel location, compositing the fragment representing closest transparent data with contents of the  
15 pixel value storage for that pixel location, and inhibiting further consideration of such detected fragment from further consideration as fragment buffer contents; and

repeating the processing of contents of the  
20 fragment buffer until no more fragments are left for consideration in the fragment buffer for the particular pixel location.

16. A method according to claim 15, wherein the repeating is performed on a fragment-by-fragment basis for fragments in the fragment buffer, with fragments not constituting the predetermined one being returned to the  
5 fragment buffer in first-in, first out format, until no more fragments are left in the fragment buffer.

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17. In a data processing system where multiple fragments representing overlapping data for a three-dimensional environment are arbitrated to determine a single image value for storage in a particular pixel location of a frame buffer, an improvement comprising:

first, identifying and storing a first fragment in a first buffer, with remaining fragments representing overlapping visible data being stored in a second buffer, where the first fragment represents a predetermined one of closest and furthest visible data from a desired viewing perspective;

second, generating an index that permits retrieval of the first fragment with respect to fragments in the second buffer for the particular pixel location, and storing the index in a third buffer; and

third, using the contents of the third buffer to identify and remove a fragment from the second buffer in dependence upon depth, and blending the removed fragment with contents of the first buffer.

18. An improvement according to claim 17, wherein:

the first buffer is part of a frame buffer and the frame buffer includes a pixel value storage unique to the particular pixel location;

the second buffer is a fragment buffer that collectively holds fragments for multiple pixel locations; and

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the third buffer is a Z-value storage  
corresponding to the particular pixel location.

19. In an image processing system where multiple  
fragments representing overlapping data are arbitrated  
to determine a single value representing a particular  
pixel location of a viewing image, an improvement  
5 comprising:

placing multiple fragments into a fragment  
buffer;

polling fragment buffer contents to identify a  
predetermined one of maximum and minimum Z-value  
for fragments for the particular pixel location;  
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moving the identified fragment to a frame  
buffer, combining that fragment with any  
preexisting contents that are to be visible in  
an output image, and removing the identified  
fragment from further consideration as fragment  
buffer contents; and  
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repeating the polling and moving until no  
further fragments are left for the particular  
pixel location.

20. An improvement according to claim 19, further  
comprising:

storing fragments corresponding to many pixel  
locations, all collectively in the fragment  
buffer;  
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returning fragments not corresponding to the  
predetermined one into fragment buffer for  
later-consideration as a predetermined one; and

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10 performing the repeating until no fragments are  
left in the fragment buffer.

21. An improvement according to claim 19, further  
comprising:

compositing fragments for overlapping visible  
data in back-to-front manner, by

5 first, polling the fragment buffer to  
identify any fragment representing closest  
opaque data for the particular pixel  
location and moving such fragment to a frame  
buffer,  
10 second, culling fragments obscured by the  
closest opaque data, and  
third, identifying and compositing with  
contents of the frame buffer each fragment  
remaining in the fragment buffer  
15 representing furthest data for the  
particular pixel location.

22. A data processing system that blends multiple  
fragments each representing visible imagery from a  
viewing perspective, comprising:

5 means for identifying and storing any fragment  
representing closest opaque data or furthest  
transparent fragment if there is no closest  
opaque data; and

means for successively detecting and blending  
with the stored fragment in order of greatest  
10 depth each remaining fragment representing  
furthest unprocessed unobscured visible data.